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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Determination of Color in Petroleum Oils

Exhaust Gas Poisoning

Some Motor "Lubrication Failures" due to Hidden Causes

PUBLISHED MONTHLY BY
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Determination of Color in Petroleum Oils

THAT color bears no relation to the behavior of petroleum distillates is the assertion made by most text books on this subject. At first sight, it would be difficult to argue that the efficiency of gasoline, the burning quality of kerosene, or the lubricating value of an oil depends on its color. Yet, looking at the subject from different angles may bring out some points of interest.

It may be said of the more common vegetable oils, such as olive, cottonseed, peanut or linseed, that their essential properties as regards edibility and industrial use, are not affected by color. Yet the manufacturers seek to turn out a bright, clear, pale product. The consumer has been educated to look for these in the oil as a mark of quality and a measure of refinement. The preference for refinement is shown both over the counter and in the written specification. Is it only because of appearance? Partly, yes. After all, appearance does play some part in our choice of most, if not all, commodities. Appeal to the eye is not infrequently the result of excellent workmanship.

But purity and color often go hand in hand, for in treating and filtering these oils to obtain maximum purity, the coloring substances are eliminated. Assuming even that all essential properties for certain uses of two oils are identical, the buyer instinctively favors careful refinement.

This applies equally well to most types of mineral oils. In treating to remove the tarry, resinous, oxidizable and suspended substances, the color is improved with the thoroughness of the process. Whatever the normal depth of color for a particular class of oil may be, it diminishes with the extent of additional refinement. In such special oils as textile machinery lubricants and paint thinners, the color value is a considerable factor. Steam turbine and transformer oils, which are highly refined to meet stringent requirements are relatively lighter than other oils of the same viscosity. Low color may just accompany, or often even determine suitability. In the case of gasoline, yellowish, off-color material is looked upon with suspicion as naturally as dirty drinking water. For internal combustion engines it may readily be expected that a clear pale oil will result in a minimum of carbon formation, and experience has shown this generally to be a fact.

In the refinery, measurements of color are most important. Experience has shown in regard to any particular class of crudes, that a certain method of refining brings about a definite desired result. It is the aim of the refiner to have his product always uniform and according to the specification which has been found in practice to be most satisfactory. In determining this uniformity, and whether a refining process has been completely successful or not, the measurement of color is an important guide. It does not tell the whole story but it gives a strong indication as to what may be expected from other tests and is a good check as to the proper carrying out of the process.

For this purpose various types of tintometers,

or color measuring instruments, have been developed. From the early rough comparison in the ordinary four-ounce sample bottle, there have recently been evolved some very elaborate and excellent examples of the instrument-maker's art. The results obtained, however, must depend largely on the individual skill and clear vision of the operator. It has been observed that the personal element plays an important part in color work. Figures which the same operator will check often, vary considerably from those arrived at by another perhaps equally skilled.

The instruments used in the determination of color in oils can be classified into three types.

1. A cell of standard dimensions is compared with a succession or addition of slides of a given series.

2. A color glass is used as a standard, and variations are made in the depth of the oil until a match is obtained.

3. An oil or liquid of known intensity is compared with the one under test, the depth of one or the other being varied to get a match. From the depth of the columns the color is computed by simple proportion.

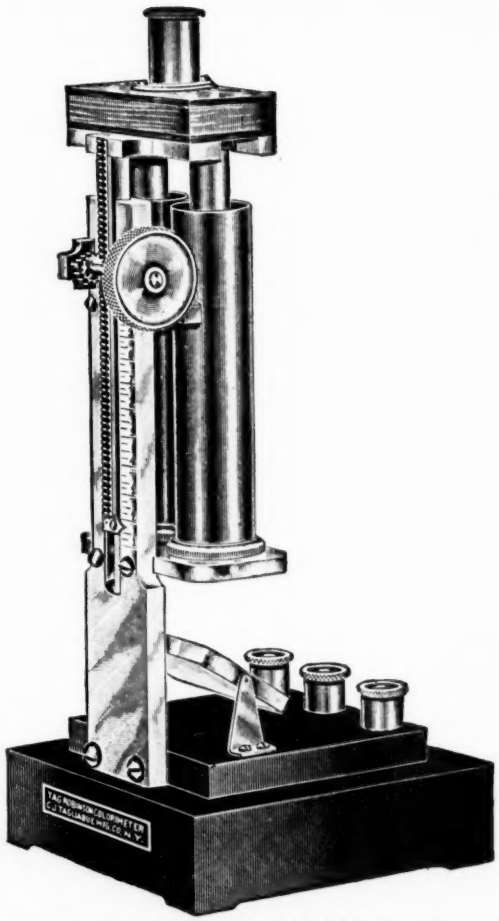

Fig. 2.—THE TAG-ROBINSON COLORIMETER. The oil is poured into the metal container, and a glass bottom cylinder moved up and down in the oil by means of the rack and pinion device shown. The color is compared with any one of the three standard glasses, which is screwed into the metal cylinder on the opposite side. Reading is taken in cm. on the graduated scale shown, conversion being made to the arbitrary scale of the instrument, depending on the glass used, by means of the table supplied with the apparatus.

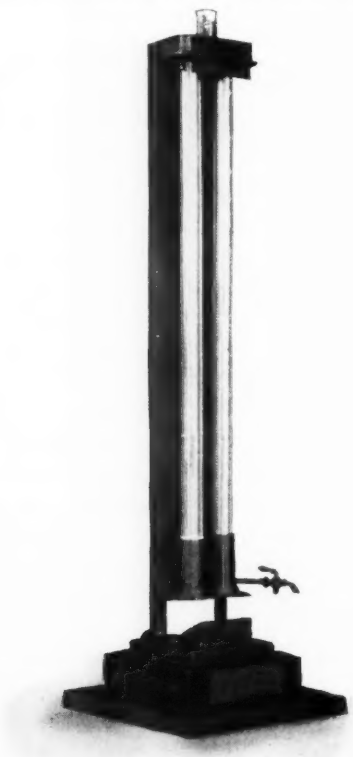

Fig. 1.—THE SAYBOLT UNIVERSAL CHROMOMETER. The oil is poured into the graduated tube on the right and compared with the standard glass at the bottom of the tube on the left, by draining the oil through the pet cock shown at the bottom.

Under Class 1, we have the Lovibond Tintometer, the National Petroleum Association (N.P.A.) Colorimeter, and a very recent elaborate and well made instrument, the Wesson Oil Colorimeter.

Under Class 2 comes the Saybolt Universal Chromometer, the Tag-Robinson, and the not very common Stammer Colorimeter.

The Duboscq Colorimeter stands practically alone as the third type.

Each instrument has its advantage due to certain individual features and applications.

Fig. 3.—THE DUBOSCQ COLORIMETER. The oil is poured into either one of the two cylinders and compared with the liquid color standard in the other container by adjusting the respective depths through operation of rack and pinion in back of instrument. The prisms are of optical glass and dipped down in the oil so that a raising or lowering of the cylinder varies the depth of liquid observed.

The N.P.A. Colorimeter, for instance, is extremely simple to manipulate. The oil is compared in a four-ounce bottle with a series of standard glasses. On the other hand, the extreme shortness of column diminishes the sensibility of the test. Oils that show approximately the same color by this system will show distinctly different values in a longer column. There is always the uncertainty as to the color of the glass bottle and its diameter is by no means uniform.

The Saybolt Universal Chromometer permits the observation of an oil column 20 inches deep and compares the oil with one or two glasses as needed. Light is reflected simultaneously upwards through the comparison slide and the oil column into a split field comparison ocular. The test is started with the graduated tube full of oil which is then slowly drained through a small pet-cock, until a satisfactory comparison is made. The depth is then read off on the scale in inches, and by referring to a table supplied with the instrument, a corresponding figure in Saybolt color shades is obtained. It is intended for use with gasolines and kerosenes only, so that another system must be used for oils that fall beyond this rather limited range.

The Tag-Robinson Colorimeter, while comparatively new on the market, is old in principle, and is intended for testing lubricating oils. Its sensibility is greater than that of the N.P.A., as it has a cell depth of 9 cm. ($3\frac{1}{2}$ inches). The optical system employed is much the same as in the Saybolt Chromometer. A rack and pinion device which raises and lowers in the oil cell a hollow metal cylinder with glass bases, gives in this manner a variable depth of oil column. The reading is indicated by a pointer that plays over a scale divided in 0.25 cm. Conversion is then made to an arbitrary scale depending on which of the three comparison glasses was needed in making the test.

The Duboscq instrument is adapted for intercomparison of liquids. Its excellent optical equipment and mechanical construction make it suitable for precision work in color comparisons of this type. The use of a liquid standard is, however, in itself a drawback, and the necessary computations in making tests put the instrument at a disadvantage for rapid routine work. Its maximum depth of cell, which is 10 cm. (4″), compared with the Lovibond 6″

Fig. 4.—THE WESSON COLORIMETER. The oil is placed in a standard cell, which is inserted in the vertical housing. Comparison is made by adjusting wedges with operating knobs. Knobs may be observed at the right of eye-piece. Source of illumination is in the lamp housing which serves as a base.

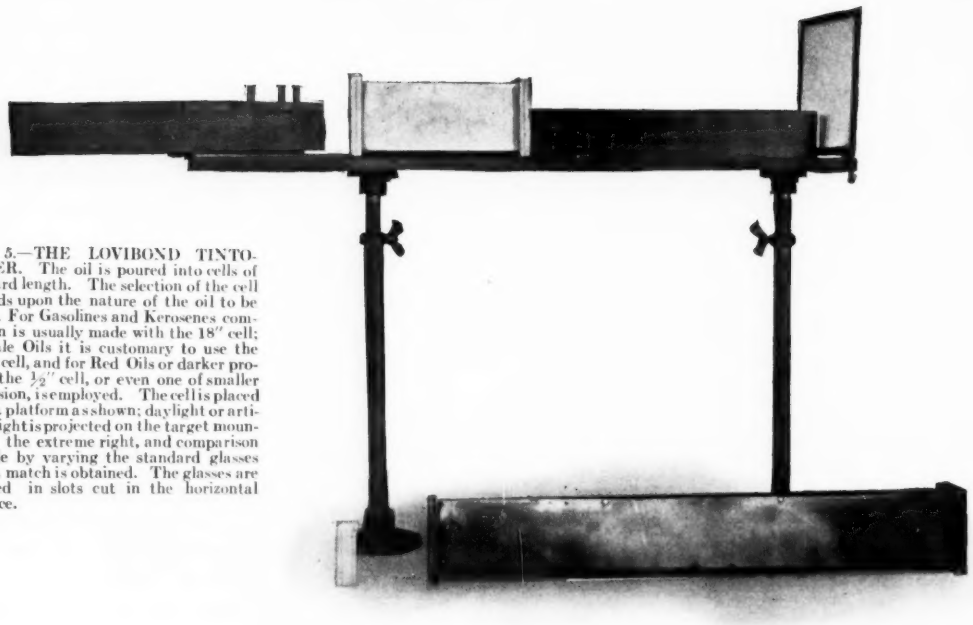

Fig. 5.—THE LOVIBOND TINTOMETER. The oil is poured into cells of standard length. The selection of the cell depends upon the nature of the oil to be tested. For Gasolines and Kerosenes comparison is usually made with the 18″ cell; for Pale Oils it is customary to use the 6 inch cell, and for Red Oils or darker products the $\frac{1}{2}$″ cell, or even one of smaller dimension, is employed. The cell is placed upon a platform as shown; daylight or artificial light is projected on the target mounted on the extreme right, and comparison is made by varying the standard glasses until a match is obtained. The glasses are inserted in slots cut in the horizontal eyepiece.

cell for pale oils, and the 18″ cell for light refined oils, cuts down its comparative sensibility to some extent.

The Wesson instrument matches against the oil various portions of red, yellow and neutral tinted wedges, operated by rack and pinion. The position of the wedges is indicated by a numbered scale, which is taken as the color indication. The use of a neutral tinted wedge has been found to be of great assistance in accurately matching oils, as it supplies an arbitrary value for the light absorbed in the sample. The operator is therefore enabled to match oils in instances where the tint is the same as that of the comparison glass but the intensity different. The instrument, however, has the usual drawback of having too short a cell (10 cm.) so that significant differences can not be seen on gasolines and kerosenes. Then, too, the sum of the comparison units is small, so that with oils of about 150 Lovibond, it becomes necessary to dilute the sample or reduce the length of the column. Barely perceptible differences in the red and neutral scales necessitate excessive compensations of yellow in balancing the field.

As a whole the colorimeter is of excellent design and workmanship. Its optical and mechanical adjustments are precise and convenient of operation. There is no doubt that, by applying the essential principle of this design, with slight modifications, a very satisfactory petroleum oil colorimeter would be obtained.

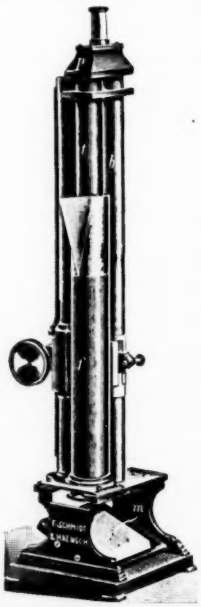

Fig 6.—THE STAMMER COLORIMETER. The oil is poured into the lipped metal container "f" and a glass bottom hollow cylinder is moved up and down in the oil with rack and pinion. Reading is taken in cm. on scale shown. One or more comparison glasses, as needed, is placed on top of the tube "b".

The Lovibond instrument has the elements that make it most adaptable to rapid and accurate testing and for plant control. The comparison slides of the 500 or amber series contain a fixed ratio of red and yellow, and are a close match with petroleum oils when viewed by means of transmitted light. Off-shade oil in which, for example, there is a preponderance of red can not, of course, be matched with any degree of precision. Separate yellow, red and blue glasses could be used to accurately match

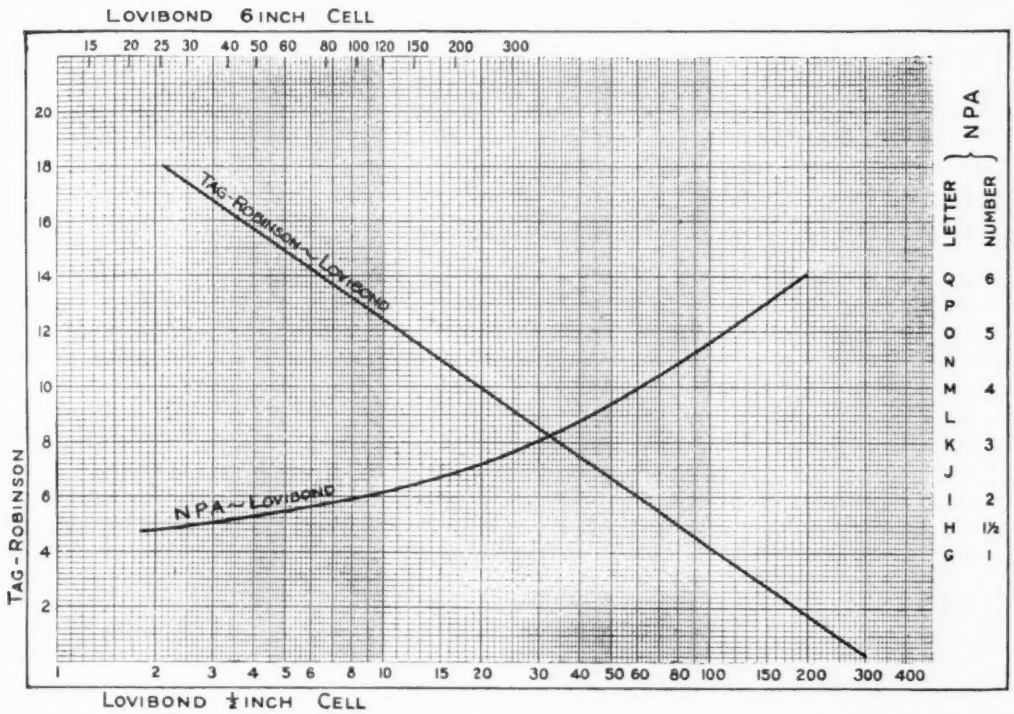
LOVIBOND 6 INCH CELL
15 20 25 30 40 50 60 80 100 120 150 200 300
TAG-ROBINSON
20 18 16 14 12 10 8 6 4 2
TAG-ROBINSON ~ LOVIBOND
N.P.A. ~ LOVIBOND
LETTER
NUMBER
N P A
G H I J K L M N O P Q
1 1½ 2 3 4 5 6
1 2 3 4 5 6 8 10 15 20 30 40 50 60 80 100 150 200 300 400
LOVIBOND ½ INCH CELL

Chart 1.—Conversion between Tag-Robinson, N. P. A., and Lovibond Color Units. In this chart the Lovibond 6″ cell is assumed to give 12 times the depth of color of a ½″ cell. With some oils this is not strictly correct for the higher units. The straight line should be used with left hand scale and bottom or top, while the curve line should be used with the right hand scale and bottom or top.

oils of this type. It is found, however, that for refined petroleum oils, the number of off-shade samples is relatively small. The advantage of obtaining a close match on oils of this kind, by readings on three sets of glasses, is almost negligible. On the other hand, the 500 series provides an adequate means of testing samples with one set of glasses, from the lightest naphtha to those of lubricating oils on which a color reading is of any value.

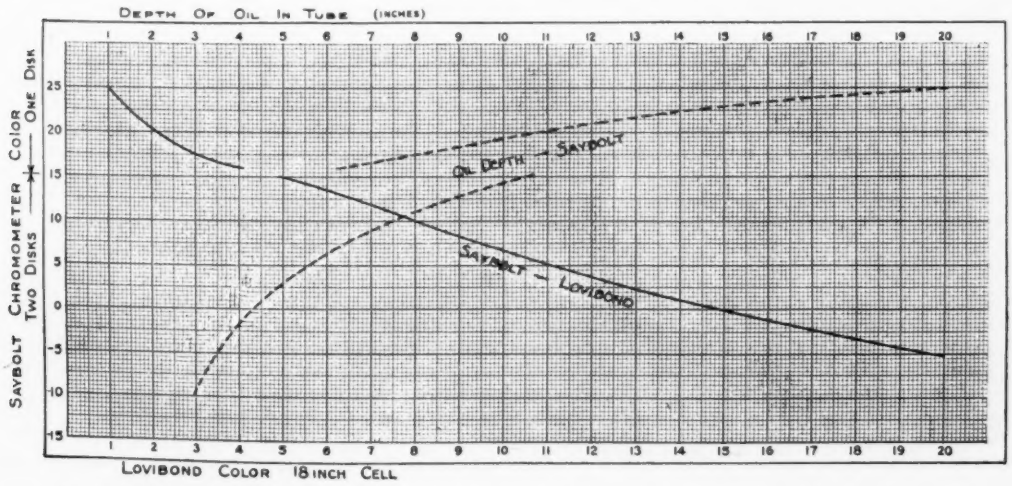
DEPTH OF OIL IN TUBE (INCHES)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SAYBOLT CHROMOMETER COLOR
TWO DISKS ——— ONE DISK
25 20 15 10 5 0 -5 -10 -15
OIL DEPTH ~ SAYBOLT
SAYBOLT ~ LOVIBOND
LOVIBOND COLOR 1 INCH CELL

Chart 2.—Conversion between Saybolt and Lovibond Color Units. The heavy lines shows the relation between the units, while the dotted line shows the relation between the Saybolt units and the depth of oil in the tube.

The point was raised in a recent scientific paper that the Lovibond units are not additive. The author pointed out that the Lovibond reading showed an increasing deviation from the true color as the depth increased. An oil having a true color of 760 reads 790 in a ¼″ cell. In the first place, an error of 30 points on a reading of nearly 800 is almost within the limit of experimental error, and then again: of what value is a color on an oil that is almost opaque? This may be readily seen when the true color of red oil in a ¼″ cell, equal to No. 6 N.P.A., was given as 120.

In the range of light refined, pale and red filtered lubricating oils, the Lovibond offers the simplest and most accurate method. For the oil testers, there is no computation, no verniers to read, or other complicated manipulations. Then, too, the results are easily understood in the plant. To show small variations where the readings are low, the length of cell is increased proportionately. From a ½″ cell for red oils, a 6″ cell for pale oils, we go to an 18″ cell for gasolines and kerosenes. To avoid confusion certain cells are assigned to definite groups of products.

COMPARATIVE COLORS

Lovibond Tintometer Readings (500 Series) and Wesson Oil Colorimeter

Product	Lovibond	Wesson Oil Colorimeter			
		Red	Yellow	Neutral	Depth of Oil
	(18″ Cell)				
1. Gasoline	1.1	0.0	0.2	0.0	10 cm.
2. Spirits	1.6	0.0	0.4	0.0	10 cm.
3. Kerosene	3.0	0.0	1.0	0.0	10 cm.
4. Extra Pale Oil	3.8	0.0	1.5	0.0	10 cm.
	(6″ Cell)				
5. Extra Pale Oil	15.5	0.0	12.7	0.0	10 cm.
6. Lard Oil	18.0	1.2	10.4	1.2	10 cm.
7. Pale Oil	33.5	0.0	29.0	1.0	10 cm.
8. Pale Oil	48.0	1.5	44.3	0.0	10 cm.
9. Pale Oil	56.5	1.4	43.6	1.4	10 cm.
10. Pale Oil	56.5	3.3	41.4	0.7	10 cm.
11. Pale Oil	94.0	4.2	56.4	1.0	10 cm.
12. Pale Oil	112.0	4.9	96.3	1.2	10 cm.
13. Pale Oil	132.0	8.2	93.9	0.2	10 cm.
14. Pale Oil	142.0	1.5	90.5	1.4	5 cm.
15. Pale Oil	219.0	1.8	31.2	2.3	2 cm.
16. Pale Oil	230.0	1.5	40.1	3.0	2 cm.
17. Pale Oil	226.5	0.7	61.0	1.6	2 cm.
18. Pale Oil	264.0	0.6	64.7	1.6	2 cm.
	(½″ Cell)				
19. Red Oil	57.0	10.5	89.6	11.7	2 cm.
	(1.2″ Cell)				
20. Red Oil	91.5	7.0	99.1	8.6	1.25 cm.
	(½″ Cell)				
21. Red Oil	110.0	6.2	94.1	8.9	1.0 cm.
22. Red Oil	150.0	2.5	73.7	6.1	0.5 cm.

COLOR QUANTITIES OF SERIES 500 EXPRESSED IN EQUIVALENT UNITS OF PRIMARY LOVIBOND COLOR STANDARDS

ARBITRARY SERIES 500	PRIMARY STANDARD GLASSES	
Unit Values	*Red*	*Yellow*
.25	.02	.22
.5	.03	.58
1.0	.03	1.2
1.5	.03	1.85
2.0	.05	2.4
3.0	.3	3.3
3.5	.32	3.7
4.0	.32	4.3
4.5	.32	5.0
5.0	.32	5.8
5.5	.46	6.0
6.0	.5	7.6
7.0	.8	8.2
8.0	.95	8.8
9.0	.95	9.8
10.0	1.0	11.0
11.0	1.0	11.55
12.0	1.1	12.5
13.0	1.25	13.5
14.0	1.3	15.0
15.0	1.4	16.5
16.0	1.45	17.5
17.0	1.55	18.0
18.0	1.65	19.0
20.0	1.85	21.0
40.0	4.0	31.0
50.0	5.0	32.5
60.0	6.0	46.0

The instrument, as placed on the market, could well be improved optically and mechanically. The wide separation of the squares of light is a defect which makes it difficult for some operators to get accurate tests. This has been overcome by a slight modification, which makes it possible to attach a split field comparison ocular.

Experience has shown that the use of a standard artificial source of illumination is of great advantage. If properly installed, it enables operators to make determinations at any time of the day or night and regardless of weather conditions. It is also helpful in producing concordant results, since if daylight is used as a source of illumination the different intensities and color effects at various localities might tend to introduce some inaccuracies.

The need for an instrument that will express in absolute units the color value of an oil and at the same time give readings which are of value to the refiner as well as the purchaser of oils, can not be too strongly emphasized. An instrument of this type is always preferable to one employing arbitrary scales or units,

unless every one standardizes on the same instrument. At present, due to multiplicity of types, there is considerable confusion even with conversion tables which at best can only be approximately accurate. While some progress along absolute lines has been made by manufacturers who have placed spectro-photometers on the market, there is still a great deal of development to be accomplished in this field. The use of an instrument of this type has many drawbacks, due both to cost and the difficulty of manipulation, but it is hoped that they may be overcome, and an instrument developed that will be accurate, easy to manipulate, and easily standardized. Until then we must maintain our present standards.

Exhaust Gas Poisoning

REPORTS are received almost daily of men being overcome or even killed by the exhaust gases from an automobile run in a closed garage. The conditions here are almost identical with those which may exist in the vehicular tunnel, which is about to be constructed under the Hudson River. In order to study this problem accurately it was considered of sufficient importance to warrant bringing together the services of the Bureau of Mines and the Research Departments of the Universities of Illinois and Yale. Some of the facts brought out in this investigation are of such great importance that they should be considered seriously by all automobile owners, especially those who have private garages and make repairs at home.

It appears that there are in general but two elements injurious to life, which may be present in exhaust gases: unburned gasoline or other fuel vapors, and carbon monoxide. These gases need not and will not be present with a properly designed and adjusted intake system which will result in complete combustion. Of these carbon monoxide is the more insidious and the cause of more deaths. It will always be present when a carburetor is set for a rich* mixture which drivers find so desirable when rapid acceleration is more desirable than a large mileage from a gallon of fuel.

The properties of carbon monoxide which make it dangerous are interesting—for in reality it is not poisonous—and it has no odor by which its presence is revealed. Its damages is not one of destroying tissue, but of shutting off the supply of oxygen to the tissues. One of the principal functions of the blood is to carry oxygen throughout the body. This it does by means of the red blood corpuscles which absorb the oxygen in the lungs much as sponges absorb water. The peculiar action of carbon monoxide is that the red blood corpuscles have a much greater affinity for it than oxygen—some 300 times more. Accordingly if any carbon monoxide gets into one's lungs it will at once be absorbed and leave a smaller number of blood corpuscles to carry oxygen. This can be continued until the quantity of oxygen carried is too small for the needs of the body, and physical collapse results. The two particular phases of this asphyxiation worthy of attention are: What is the maximum percentage of carbon monoxide allowable in the blood before physical discomfort results; and: How long can a person be exposed to the gas before this percentage is reached?

Experiments carried on with nine men and one woman, showed that an amount up to about 20% of the total carbon monoxide which can be absorbed (called saturation) resulted in no physical discomfort, but above this concentration the liability to headaches was increased. As much as 30% to 35% saturation resulted in severe and throbbing headaches, some of the patients experiencing nausea and vomiting. A concentration of 65% renders a man unconscious and totally helpless. Experiments with dogs showed concentrations of about 85% at the point of death.

There is apparently no danger from carbon monoxide poisoning if a headache is taken as a warning and a patient immediately returns to fresh air, though it may require several hours

*July 1921 Lubrication, page 6.

to throw off the headache. No more permanent effects are evident.

The rate of entry of carbon monoxide into the blood depends on the rate and depth of breathing, the concentration of the gas in the air and the concentration in the blood. An average man's blood corpuscles will absorb about 600 cc. of oxygen, or about the same volume of carbon monoxide if completely saturated. Thus if 6 cc. are taken into the lungs the blood will become 1% saturated with it, and at the same time 1% of the oxygen will be displaced. At rest, a man breathes about 8000 cc. of air per minute, some 6000 cc. of which reach his lungs. While walking he will inhale about twice as much, and if working, at least three times as much. Since carbon monoxide can not be absorbed more rapidly than it enters the lungs, it would require at least 10 minutes for the blood to reach 1% of its saturation when inhaling air containing 1 part carbon monoxide in each 10,000 parts of air. The more rapid the rate of inhaling, as would result from exercise, the shorter will be this period. But fortunately the rate at which it is absorbed decreases as the concentration in the blood rises, and it is only the first trace that is absorbed as fast as it enters the lungs. Finally it is absorbed no more rapidly than it is thrown off. A point of equilibrium is thus reached which varies with the concentration of carbon monoxide in the air inhaled. Thus permanent exposure to one part of carbon monoxide in 10,000 of air would never result in more than 17% in the blood, which is not likely to cause discomfort. In the same way exposure to 3 in 10,000 would result in 37%, 4 in 10,000 to 45%, and 7 in 10,000 to 58%. Fortunately again, considerable time is required for these equilibrium concentrations to be reached, and by actual experiments with several people it has been found that over an hour is necessary for the blood concentration to be raised to one half the equilibrium percentage. Thus an hour's exposure to a 4 in 10,000 mixture of carbon monoxide will rarely cause discomfort, and much higher concentrations will cause no more effect in cases of exposures of still shorter periods. Of course, some people are somewhat more susceptible than others.

Many of these experiments were carried on with pure carbon monoxide, particularly those of high concentrations with dogs. Several further experiments were made with impure gas from various sources to show their relative toxic properties. These showed that 84% pure carbon monoxide was equivalent to 72% carbon monoxide from illuminating gas, 83% from an automobile exhaust burning gasoline, and 62% with coal distillate as fuel.

Exposure to unburned gasoline vapor is also quite dangerous, though larger quantities are required to produce harmful physiological effects. The odor generally also is sufficiently pronounced as to give warning, though a man running a car in a closed garage may become so accustomed to the odor that it is not noticed. 100 parts of vapor to 10,000 of air will cause convulsions and 250 parts per 10,000 of air will cause death.

Summary

It is thus seen that the ill effects from carbon monoxide are more similar to strangulation than poisoning, and no anti-toxin would or could be of any assistance for one overcome by it. First aid measures should be with a pulmotor or artificial respiration as with patients overcome by electric shock or drowning. A short exposure will never result in injury nor serious discomfort if warning is taken at the first symptom of headache. Carbon monoxide is a little lighter than air and will be least concentrated near the floor.

The best means of side-stepping the ill effects from exhaust gas, however, is to remove the cause by eliminating the presence of carbon monoxide from exhaust gas. As has been pointed out in a previous article,* its presence is a direct indication of incomplete combustion of fuel,—and will always be associated with carbon deposits and diluted motor oil.

Thus, to avoid danger:

1. Run on as lean mixtures as practical.

2. Don't use the choke if it can be avoided, especially in a small garage.

3. Have plenty of ventilation in your garage.

Some Motor "Lubrication Failures" Due to Hidden Causes

MUCH has been written concerning the deterioration of automobiles from lack of lubrication due to insufficient care in watching the lubricating system. It has not been so completely brought out, however, that there may be a lack of proper lubrication and yet the operator be not aware of it from such examination as he may ordinarily make of his lubrication system. This condition would not usually be classed as due to neglect.

Fig. 1 shows a carburetor with dirt removed from the float chamber and is well worth studying. Note the burred condition of the plugs at the bottom of the well, and float chamber. This is due to the fact that it was easier to remove the plugs in an attempt to clean the carburetor than it was to remove the carburetor. Attention is also called to the worn condition of the needle point.

It is practically impossible to adjust a carburetor when it is in this dirty condition. Due to the fact that the passages are partly obstructed with dirt and sediment, the mixture would be too lean and the carburetor must be adjusted. This is difficult under the conditions and at best is only a temporary relief and a shifting of the sediment may change the whole adjustment. Rather than juggle the carburetor frequently it is more general practice to try to get a proper mixture by the manipulation of the choke. This is much easier and better running will manifest itself immediately.

But it is practically impossible to produce a proper mixture by this method and the tendency is to overdue the action of the choke. The result is that the mixture is too rich for satisfactory burning and a large amount of fuel is absorbed into the lubricating oil film. This diluted lubricating oil will pass the piston and rings more readily, greatly diluting the supply of oil in the crankcase. As an example a certain truck run with partly closed choke absorbed a

Fig. 1.—Disassembled carburetor showing condition of adjusting nuts and needle point. The dirt shown in the foreground was taken from around the needle point and had passed through the filtering screen.

gallon of gasoline in the lubricating oil in about ½ hour. While this may be an exception, it shows clearly the tendency for gasoline to absorb in the lubricating oil.

The operator is apt to be fooled when operating with a carburetor in the condition previously described and be led to believe that he is operating very economically in regard to lubricating oil, as his indicator will show that very little oil has been used during the trip. The quantity of lubricating oil that has been used has been partly replaced by gasoline leaking or working past the piston.

Due to the improper conditions existing in the cylinder, a lack of power is experienced, the throttle is opened wider, the engine begins to overheat and on account of the weakened lubricating oil film we have scored pistons, rings, and cylinders, and we may even have burned out bearings. And yet the operator reports truthfully that "Enough oil was in the engine, the gauge was working, the pump was working and pressure was registered on gauge until bearing burned out."

The remedy is obvious: *the choke should never be used* except to start the engine; oil should be drained out periodically, more often in cold weather, and every effort should be made to instruct the operator as to the proper manipulation of various adjustments and the importance of keeping the lubricant in proper condition.

Fig. 2.—Taper Roller Bearing damaged on account of being improperly adjusted in mounting a wheel.

The failure of taper roller bearings shown in Fig. 2 was naturally ascribed to lack of lubrication, as the bearing was practically dry when taken out of the wheel. The failure, however, was traced to the removal and mounting of the wheel by operator in order to replace a broken

Fig. 3.—Roller Bearing damaged by an attempted adjustment which could not be made, as the rollers were straight. Due to the end thrust caused by this attempted adjustment, the flange on the end of rollers was forced into the grooves on cone and cup, thereby causing cutting.

brake spring. The wheels are heavy and it is easy to damage the bearing by bending the retainer out of shape when mounting the wheels. The rollers are thus thrown out of line with the cone and cup and the friction thus generated uses up the lubricant. Particles of the retainers soon find their way between the bearing surfaces with the usual result.

A taper roller bearing can be adjusted for wear, but in the illustration showing a straight roller bearing (Fig. 3) we see the result of an attempted adjustment on a bearing of this kind. A flange was provided on the rollers to keep them in alignment with the cup and cone, but the end thrust applied (due to the attempted adjustment) caused the flange on the rollers to cut into the cup and cone, chipping them considerably. It is usual to find bearing surfaces dry or nearly so when operated under such conditions, as the great amount of friction and heat thus created will readily use up the lubricant.

It will be seen from the foregoing that instructions to operators regarding ample pro-

Fig. 4.—Rear Axle Drive Shaft showing crystallization probably due to excessive strains. These strains no doubt were caused by poorly adjusted or improperly used clutch, hauling vehicle out of mud holes, bad roads, and overloading.

Fig. 5—Brake shoe after only 30 days running. Investigation showed that the truck had been sent out from the shop without the spring which holds the shoe in proper position. Carelessness of this type is dangerous and the only cure is rigid inspection.

vision of lubricant will not always cover the case. The operator should not be blamed unless it can actually be shown that he was negligent. It will be noted that in the first illustration the failure was due to lack of proper lubrication, but that this fact would not be apparent to the average operator. In the last two illustrations the failure was *apparently* due to lack of lubrication, but actually due to mechanical defects. An educational campaign is the only method of providing against such contingencies.

The owner of motor equipment seldom realizes that, due to failures as previously described, he indirectly pays a large sum to educate his operator. He obtains only too readily the services of a new man, who, as likely as not, will be the cause of similar catastrophes as his predecessor, even though his intentions may be of the best.

The best method of education would be to send the operator to the shop where repairs are being made on the equipment which failed while under his care, and there show him the "why and wherefore." Better service will no doubt be obtained by keeping the operator on the same type of machine. When a change is made it will take some time before the operator thoroughly familiarizes himself with his new charge and it is this period which is probably responsible for most failures, even though the actual lay-up may not be necessary until some time later.

It must be realized that while lack of lubrication will in time always cause mechanical failures, all mechanical failures are by no means due to this cause. Faulty metals, poor design, careless alignment or adjustment, can never be corrected by lubrication. This is certainly obvious—but it is frequently lost sight of.

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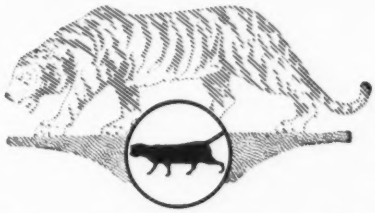

Family Resemblance

NOTWITHSTANDING some differences in particular features, there is a strong family resemblance between the automobile engine and the Diesel engine.

In fact, figuratively speaking, it may be said that the automobile engine is to the Diesel engine as the house cat is to the "lord of the jungle."

So, then, it is not strange that the lubricants, which are best suited for the automobile engine, should have so many points in common with the best lubricant for the largest member "of the internal combustion family."

Consequently,

TEXACO MOTOR OIL
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and
TEXACO URSA OIL
for Diesels

have certain marked family traits.

To illustrate:

1. Both burn completely in the cylinders.
2. Both have the ability to withstand the high heat of the internal combustion engine.
3. Both have a low pour test (used to determine fluidity under low temperature).
4. Both lubricate thoroughly.
5. Both are free from gummy deposits—the chief cause of hard carbon.

   Hard carbon is largely caused by unburned or non-combustible matter (road dust, etc.), sticking to the gummy deposits and then literally being baked onto the heat exposed metal surfaces.

   Therefore, because of this lack of gummy deposits, Texaco Motor Oil in the automobile engine and Texaco Ursa Oil in the Diesel, insure the clean and free operation of valves and piston rings and freedom from misfiring and pre-ignition.
6. Both are uniform. The two quart "Easy Pour" can of Texaco Motor Oil you buy in your city always contains oil identical with the cargo lot that is landed at Cape Town—the barrel of Texaco Ursa Oil taken on at Bombay or Brest "tests" the same as the tank car load delivered to, let us say, the Light & Power Company in Texas—Texaco uniformity governs both.

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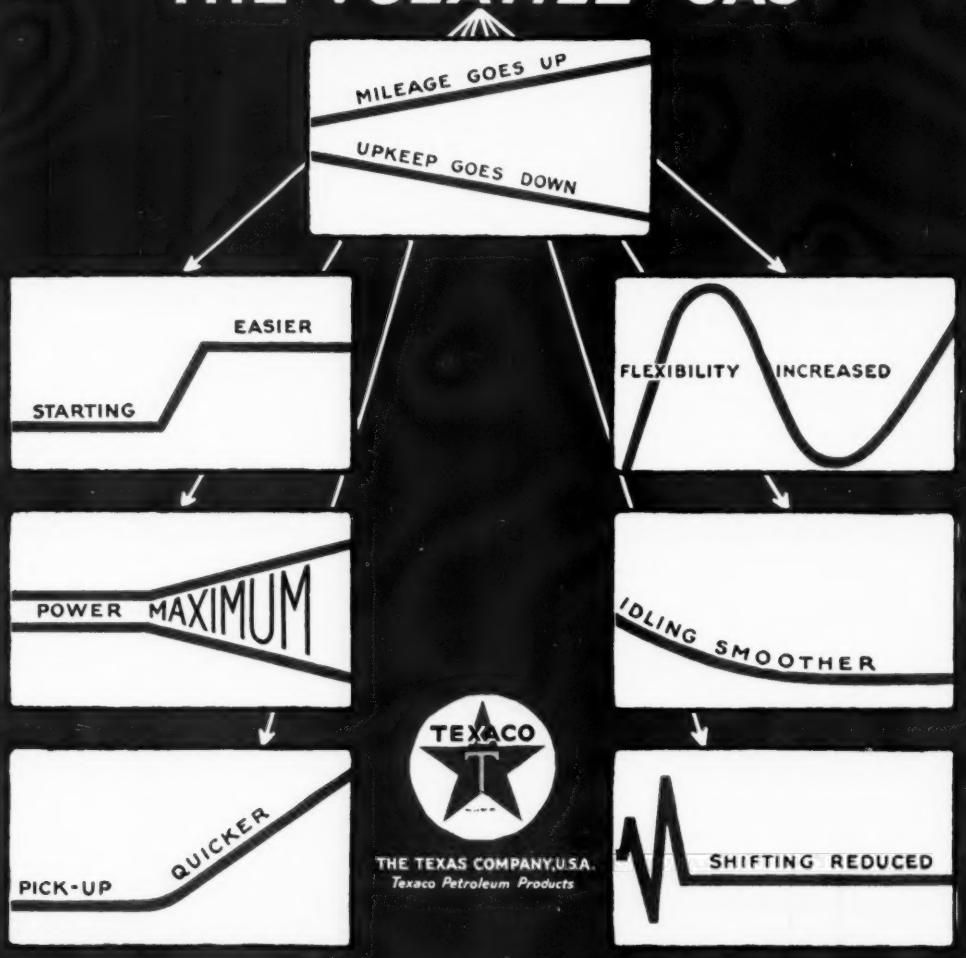

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